

## Assignment - I

-v. chandrasekhar

1)

A)

As discussed in piazza I have assumed the top-left padding which is actually given scipy.convolve2d and in tensorflow documentation.

$$I = \begin{bmatrix} 2 & 0 & 1 \\ 1 & -1 & 2 \end{bmatrix} \quad F = \begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix} \quad P \cdot I = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 2 & 0 & 1 \\ 0 & 1 & -1 & 2 \end{bmatrix}$$

$$\therefore F \times I = \begin{bmatrix} 2 & -2 & 1 \\ 3 & -4 & 4 \end{bmatrix}$$

B) Yes  $F$  is separable

$$F = F_1 \cdot F_2 = \begin{bmatrix} 1 \\ 1 \end{bmatrix} \times \begin{bmatrix} 1 & -1 \end{bmatrix}$$

Now

$$F_1 \times I = \begin{bmatrix} 1 \\ 1 \end{bmatrix} * \begin{bmatrix} 2 & 0 & 1 \\ 1 & -1 & 2 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix} * \begin{bmatrix} 0 & 0 & 0 \\ 2 & 0 & 1 \\ 1 & -1 & 2 \end{bmatrix} = \begin{bmatrix} 2 & 0 & 1 \\ 3 & -1 & 3 \end{bmatrix}$$

$\therefore$  again padded according documentation.

$$\begin{aligned}
 F_2 * (F_1 * I) &= \begin{bmatrix} -1 & 1 \end{bmatrix} * \begin{bmatrix} 2 & 0 & 1 \\ 3 & -1 & 3 \end{bmatrix} = \begin{bmatrix} -1 & 1 \end{bmatrix} * \begin{bmatrix} 0 & 2 & 0 & 1 \\ 0 & 3 & -1 & 3 \end{bmatrix} \\
 &= \begin{bmatrix} 2 & -2 & 1 \\ 3 & -4 & 4 \end{bmatrix} \quad (\because \text{padded for same dimensions})
 \end{aligned}$$

c)

$$F = F_1 F_2 \Rightarrow F(k, l) = F_1(k) \cdot F_2(l)$$

$$\therefore F * I = \sum_k \sum_l I(i-k, j-l) \cdot F(k, l)$$

$$= \sum_k \sum_l I(k, l) \cdot F(i-k, j-l) \quad [\because a * b = b * a]$$

$$= \sum_k \sum_l I(k, l) \cdot F_1(i-k) \cdot F_2(j-l)$$

$$= \sum_l F_2(j-l) \cdot \left[ \sum_k I(k, l) \cdot F_1(i-k) \right]$$

$$\boxed{F * I = F_2 * [F_1 * I]}$$

hence proved.

d)e).

a) For each element in the result we need  $M_2 N_2$  calculations.

$\therefore$  Total no of calculation are  $M_2 N_2 M_1 N_1$ , ( $M_1 N_1$  elements in total),

b) for seperable kernel there are two convolutions with  $(M_2, 1)$  and with  $(1, N_2)$

$\therefore$  Total no of calculations are  $(M_2 + N_2) M_1 N_1$

$\therefore$  The answer for d is both involve 24 calculations.

f)

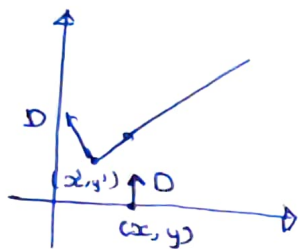
The first one is  $O(M_2 N_2)$  where as second one is  $O(M_2 + N_2)$ .

$\therefore$  The seperable kernel with 2 1-D convolutions can be done faster by seperate convolutions

( $\therefore$  The order is written in terms of change),

(1)

(a)



Given,

The grad is rotated by " $\theta$ " ("edge")

$\Rightarrow$  The derivative  $\perp^{\text{loc}}$  to edge is also rotated by  $\theta$



$\therefore$  Now the  $D_y = D \cos \theta$  and  $D_x = -D \sin \theta$ .

But The magnitude still stay's the same as  $D$  so if it is marked as edge before it is marked now also.

(b)

The suprious edges are appeared when few non-edge pixels ~~increases~~ surpasses the max-threshold and become white so to overcome this we need to increase max-threshold.

The edge-pixels even if they marked as weak they may get apperead but that is not a case that means few edge pixels are suppressed so we need to decrease min-threshold.